UNPUBLISHED PRELIMINARY DATA

EFFECTS OF DEPRIVATION CONDITIONS UPON THE RAT'S HOME CAGE BEHAVIOR[1]

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ABSTRACT

Ss were observed in their home cages and their behavior recorded by means of a behavior-sampling technique to determine how the pattern of behavior changes as a function of deprivation experience. Ss were deprived either continuously, i.e., deprived throughout the 9 days of observation, or cyclically, i.e., maintained on a daily schedule for 15 days. Relative to satiated controls, both hungry groups showed a marked increase in activity and disruption of the normal diurnal cyclicity. Relative to satiated controls, thirsty Ss showed little change. There was little difference between cyclic and continuously deprived Ss.

The recent work of Hill (1958), Strong (1957), Treichler and Hall (1962), Weasner, Finger, and Reid (1960), and others indicates that the effect of deprivation upon "general activity" depends upon what kind of apparatus is used to measure it. Deprivation appears to affect some sorts of behavior, such as running in a wheel, much more dramatically than it affects other sorts of behavior, like that which is counted in tilt cages. The implication is that the effect of deprivation on activity depends upon the kind of activity that can occur in the particular kind of apparatus that is used. But in the absence of direct observation of what animals are doing when they are being "generally active", the explanation of the discrepant findings of activity as a function of deprivation remains at the inferential level.

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In the present investigation animals were watched and their behavior was recorded in order to determine what, in fact, they do and to see how their behavior changes as a function of deprivation conditions. The method of observation was one in which S's behavior is sampled across time, and in which behavior is observed while S is in the most familiar of environments, viz., its own home cage. The question then becomes how deprivation conditions affect how Ss spend their time. The results of an earlier study using this technique (Bolles, 1963) suggested that the rat's behavior in the homecage gives little evidence of a direct activating effect of hunger deprivation, and that what changes in the pattern of activity that are found, can be attributed to conditioning. The present study expands the frame of reference: the effects of both hunger and thirst are investigated, the effects of both continuous deprivation and cyclic deprivation (i.e., maintenance schedules) are examined, and more severe deprivation conditions are imposed than was the case in the first study.

Method

Subjects

The Ss were 32 naive male Sprague-Dawley rats, about 90 days old.

Apparatus

The Ss were individually housed in regular 7 in. by 7 in. by 10 in. cages (Wahmann LC-75A), except that the hardware cloth fronts of the cages were replaced by Plexiglas to provide better visibility. Cages were mounted in four columns of four rows in a regular cage rack. The cages were located in a specially constructed isolation room which had double walls of plywood and acoustic tile and was heavily carpeted to provide good sound and vibration isolation from the environment. The isolation room provided 60 db attenuation or better of all sounds above about 200 cps. A white noise generator which produced a constant noise level of about 65 db throughout the experiment provided further masking of external noise. Observations were made from a darkened antechamber to the isolation room through a one-way window. The lights were run on a 6:00 to 6:00 natural light-dark cycle. Illumination was provided by two 60-w. bulbs and during the dark part of the cycle by a bank of four 25-w. red lights located in front of the cages. Thus, E was able to observe Ss without disturbing their natural, diurnal illumination cycle. Temperature varied over a 10° range, due mostly to the heat from the lights during the day. This extensive isolation of Ss from E, and from each other, was dictated

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by the results of the earlier study where it was found that deprived animals were exceedingly sensitive to any external stimulation. The aim of the present experiment was to study the effect of deprivation upon Ss that were as free as possible from any stimuli that might possibly serve as cues to feeding.

Procedure

The observation procedure has been described elsewhere (Bolles, 1960,1963). Briefly, it consists of E scanning the array of cages, going from one to the next in order, writing down what each S is doing. This process takes about one min. with 16 cages. In the present study this scanning process was repeated 24 times during each observation session. Thus, each session provided a sampling of 24 observations of each S's behavior during a period of approximately twenty or thirty minutes. Sixteen of these sessions were run a day, starting regularly every 90 min. All observations of S's behavior were classified into the following categories: Sleeping, recognized by the fact that S is motionless, has closed eyes, and is usually in a typical sleeping posture; Lying, which means that S is lying down and inactive but not sleeping; Lying and Sniffing, exploratory behavior while in the lying position; Standing, which means that the animal is motionless but on four feet; Standing and Sniffing, which is the most common exploratory behavior; Activity, which includes Rearing on the hind legs, Walking, Climbing, and Chewing on the cage, all of which were scored separately. This list of categories defines a continuum from minimal activity at one end to the gross bodily activities at the other. This list of categories plus the functional activities, Eating, Drinking, and Grooming (face washing, scratching, and fur licking were scored separately but are reported here as a combined grooming score) included all but about 0.5% of the observations.

With this many response categories it is difficult to discriminate sharply between adjacent categories. Although it has been found possible to train observers to show extremely good inter-observer reliability, such training was minimized in the present study. The observers were required to rely primarily upon the above verbal descriptions since at this stage in the development of this procedure generality and reproducibility of findings would seem to be more important than the reduction of variability within an experiment. The greatest difficulty was encountered in discriminating between sleeping and lying. Observer differences were not sufficiently serious to affect materially the total activity scores, however, and the discrepancies that were found were balanced out by counterbalancing observers across time of day over every two-day period.

Deprivation conditions

Two sets of 16 Ss each were observed about a month apart. In the first set the deprivation conditions were continuous, i.e., after deprivation was imposed it was continued to the end of the experiment. Ss were acclimated to the new environment and the light-dark cycle for about a week prior to the beginning of the observations. One hour prior to the first observation session (at noon) six Ss were deprived of water, six Ss were deprived of food, and four Ss were allowed to continue on ad lib. food and water. During the deprivation days the isolation room was entered only once to replenish the food and water supplies of the ad lib. Ss. By the end of the ninth day one hungry S had died, another was about to do so, and the observations were terminated at that point. After nine days deprivation both the hungry and the thirsty Ss were approximately 50% of the weight of the ad. lib. controls.

The second set of Ss was run on cyclic deprivation conditions. Again, six Ss were hungry, six were thirsty, and four were ad lib. controls. As before, all Ss were maintained ad lib. for one week prior to the beginning of the deprivation period. Deprivation was initiated one day at noon just before the first regularly scheduled observation which was at 1:00 P.M. Subsequently thirsty Ss were given water for 30 min. each day at noon and hungry Ss were given 10 to 12 gm. of Wayne Lab Blox each day at noon. These rations were usually finished by the time of the 1:00 observation session. The cyclic deprivation conditions were maintained for 15 days and observations were made every other day starting with the first. On this regimen hungry Ss lost between 15% and 25% of their initial body weight and thirsty Ss lost approximately 5%.

Results and Discussion

The overall mean incidence of different forms of behavior under the different deprivation conditions, averaged over days and over times of day are summarized in Table 1. Results are presented independently for hungry and thirsty Ss under continuous deprivation and for hungry and thirsty Ss under the cyclic deprivation conditions. Perhaps the most predominant feature of these data is the relative consistency of the pattern of behavior over the different deprivation conditions.

Thus, regardless of the deprivation conditions Ss sleep from one-half to two-thirds of the time, and spend other large portions of time lying passively, grooming and sniffing the environment. But within this consistent overall pattern there are also differences in pattern which are attributable to the deprivation conditions. Thus, hungry Ss are more active than either thirsty or satiated Ss, and this is the case no matter how the continuum between sleeping and the most active categories of behavior is split. In Table 1, the continuum has been arbitrarily split to distinguish those behaviors which are unlikely to be registered as responses by automatic recording devices as against those more active behaviors which would be detected. But whether the split is made at this point or at some other point on the continuum of activity, hungry Ss are more active than those under other conditions, both in the case of continuous deprivation and cyclic deprivation. The comparison between thirsty and satiated Ss is less impressive; indeed, if allowance is made for the reduction in consummatory behavior and in grooming (presumably due to the aversiveness of grooming with a dry mouth) there is little difference in activity between thirsty and satiated Ss. There is certainly little difference at either the most active or the most inactive ends of the continuum, but there is some indication that thirsty Ss score higher at the middle of the continuum, e.g., on standing and sniffing.

A breakdown of these data by days indicates that there are trends over days, and that nearly all of the trends are consistent and monotonic. Thus, where there are differences between conditions these differences increase over days. The only nonmonotonic trends were for lying and sniffing for the continuous hungry Ss and standing for the cyclic hungry Ss where in both cases there was a rise in the first few days and then a subsequent fall in the incidence of the behavior. Because most of the trends are monotonic, the results shown in Table 1 are reasonably representative of the pattern of behavior occurring under each of the deprivation conditions on any given day in the deprivation period. Fig. 1 shows a trend typical of those found; it presents the total of all but the two most inactive forms of behavior, sleeping and lying. These "total activity" scores rise significantly for hungry groups and decline significantly for the thirsty continuous group, while both satiated groups show a relatively constant level of activity over the course of the observations.

There was remarkably little variability within groups, so that, for example, the subtotals in Table 1 labelled Total Inactive for the continuous groups are highly significantly different ($p<.001$) even with these small-sized groups. However, there was some individualism in behavior. For example, the high incidence of miscellaneous behavior among the cyclic thirsty Ss is attributable to two Ss in that group that spent a great deal of time apparently licking the metal parts of the cage. Most thirsty Ss showed little or none of this behavior but those who did show it typically continued for periods of 10 or 20 min. engaged in some sort of oral contact with the metal.

The data were also analyzed as a function of the time of day, pooling days, and there were some clear differences as a function of deprivation conditions in the organization of behavior across the 24 hr. period. The diurnal cyclicity of activity (counting as activity all behavior other than sleeping and lying) is shown in Figs. 2 and 3. The Figs. indicate again the differences in overall activity among hungry, thirsty and satiated Ss, and indicate, in addition, that thirsty Ss differ from satiated control Ss primarily during the night, whereas hungry Ss are more active both day and night. Figs. 2 and 3 show that thirsty Ss and satiated Ss have very similar diurnal activity cycles, but that the organization of hungry Ss' behavior across time has broken down. The hungry Ss are nearly as active during the light part of the cycle as during the dark part and although their cyclicity retains a clear 24-hr. period it is severely damped and shallow. It is interesting to note that all Ss, even the hungry ones, show a sharp drop in activity and a corresponding rise in sleeping, during the first observation after the lights have come on in the morning but that whereas other groups remain asleep during the day, hungry ones come back to a high level of activity. This rebound effect might be expected of the hungry Ss fed cyclically but there is little indication from Fig. 3 of an anticipation of feeding, i.e., a sharp noise just before feeding. In fact, the cyclic hungry Ss are only a little more active than the continuous hungry Ss during the 11:30 A.M. observation. It is also clear that thirsty Ss show no anticipation of drinking under these conditions.

The cyclicity shown in Figs. 2 and 3 for all behavior other than sleeping and lying illustrates the basic diurnal cycle characteristic of all the forms of behavior. Thus, all those behaviors which are not sleeping or lying occur in approximately equal proportions throughout the 24-hr. period, so that the cyclicity of their sum, shown in Figs. 2 and 3, is reasonably representative of the cyclicity of most of the constituent behaviors. Table 2 summarizes the cyclicity of several different forms of behavior under the different deprivation conditions. The night-day ratio is simply the ratio of the mean incidence of behavior during the eight nighttime observations divided by the mean incidence during the eight daytime observations, summed across Ss within a group and across days. The overall pattern in Table 2 is one of fairly consistent ratios within each condition demonstrating the point made above, that is, the tendency of the cycles to go together.

There are also consistent differences among groups. Hungry Ss show cycles which are considerably shallower than those of thirsty Ss which are, in turn, slightly shallower than those of the satiated control Ss. There is also a slight but apparently consistent difference between continuous and cyclic deprivation conditions, the former showing somewhat less pronounced cyclicity. Both satiated groups show reasonable agreement with the rule of thumb ratio of 3.00 approximated in a variety of other situations. Consummatory behavior is the only category whose cyclicity departs markedly from the overall pattern. The thirsty Ss eat a large part of the small amount of food that they do eat in the hours immediately prior to the lights going off. On the other hand, hungry Ss, particularly those under the continuous deprivation, confine the small amount of drinking that they do disproportionately to the dark hours. The depression in cyclicity of the thirsty Ss is like that observed by Gilbert and James (1956), but these experimentors also found a further reduction in cyclicity under continuous environmental conditions (constant light) whereas the present data indicate that the night-day ratio of eating in thirsty Ss was higher in the more nearly uniform environmental conditions, i.e., the continuous deprivation group.

These results suggest some conclusions but also present a number of puzzling questions: 1) Hungry Ss in their homecages show an increase in activity with deprivation regardless of how activity is distinguished from inactivity. This is true not only for Ss who are fed regularly once a day so that there may be some conditioning of specific forms of activity to specific diurnal cues, as Bolles (1963) has emphasized, but it is true also for Ss under continuous deprivation, i.e., those who are never fed during the observation period. 2) Thirsty Ss, both those deprived continuously and those deprived cyclically, show slight increases in a number of different forms of activity but show compensatory decreases in grooming and consummatory behavior so that their total activity may be very little different from that of satiated Ss, which is a finding Campbell (1960) and Campbell and Cicala (1962) have reported in a different situation. 3) Why was there no conditioned anticipation of regular feeding in the cyclic hungry Ss like that reported under very similar conditions by Bolles (1963), and why was there no conditioning of specific forms of behavior, such as standing, during the night, as reported in the earlier study? The principal difference between experimental procedures was that the present Ss were fed in the middle of the day whereas the earlier ones had been fed one-third of the way through the night, at a time when consummatory behavior normally is at a peak. 4) Why was there no conditioned anticipation of drinking in the cyclic thirsty Ss? Such an effect has been demonstrated by Campbell (1960). 5) Why does thirst to some extent, and hunger to a marked extent, depress the normal diurnal activity cycle? And granting that such a damping effect might be expected under conditions of continuous deprivation, why was it also found here under conditions of cyclic deprivation?

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Table 1 Overall Mean Incidence of Different Forms of Behavior Under Different Deprivation Conditions (Subtotals are given in italics)

	Continuous Deprivation			Cyclic Deprivation		
	Hungry	Thirsty	Satiated	Hungry	Thirsty	Satiated
Sleep	46.4	67.6	66.1	48.7	60.4	63.4
Lie	11.6	10.5	6.7	7.6	7.6	6.7
Lie & Sniff	6.9	4.6	2.6	5.2	3.5	2.6
Stand	5.8	2.6	.6	4.0	.9	.5
Total Inactive	*70.2*	*85.3*	*76.0*	*66.5*	*72.4*	*73.2*
Stand & Sniff	8.4	3.6	1.9	13.9	7.2	5.5
Rearing	5.2	1.7	1.2	3.1	1.7	.9
Locomotion	2.5	.6	.7	1.4	.8	.7
Chewing	3.0	.6	.1	1.1	1.9	.1
Total Active	*19.1*	*6.5*	*3.9*	*19.5*	*11.6*	*7.2*
Grooming	9.3	6.0	14.4	13.2	6.2	12.3
Eat & Drink	.7	1.6	4.9	1.1	2.5	7.1
Miscel.	.5	.7	.7	.3	6.9	.4
Total	99.8	100.1	99.9	99.6	99.6	100.2

Table 2 Summary of Night-Day Ratios of Different Forms of Behavior Under Different Deprivation Conditions

	Continuous Deprivation			Cyclic Deprivation		
	Hungry	Thirsty	Satiated	Hungry	Thirsty	Satiated
Lie & Sniff	1.58	2.85	3.57	1.74	2.75	2.98
Stand	1.55	2.63	2.68	2.23	2.23	4.85
Stand & Sniff	1.68	2.31	2.69	1.50	2.38	5.43
Activity*	1.76	2.30	2.86	1.14	4.12	2.37
Grooming	1.40	2.10	2.70	1.90	2.27	2.81
Eat & Drink	4.10	1.65	2.49	1.87	1.21	3.44
Total*	1.55	2.35	2.73	1.64	2.83	3.31

* Activity here includes Rearing, Walking, and Chewing on cage. The total is for all activity other than Sleeping and Lying.

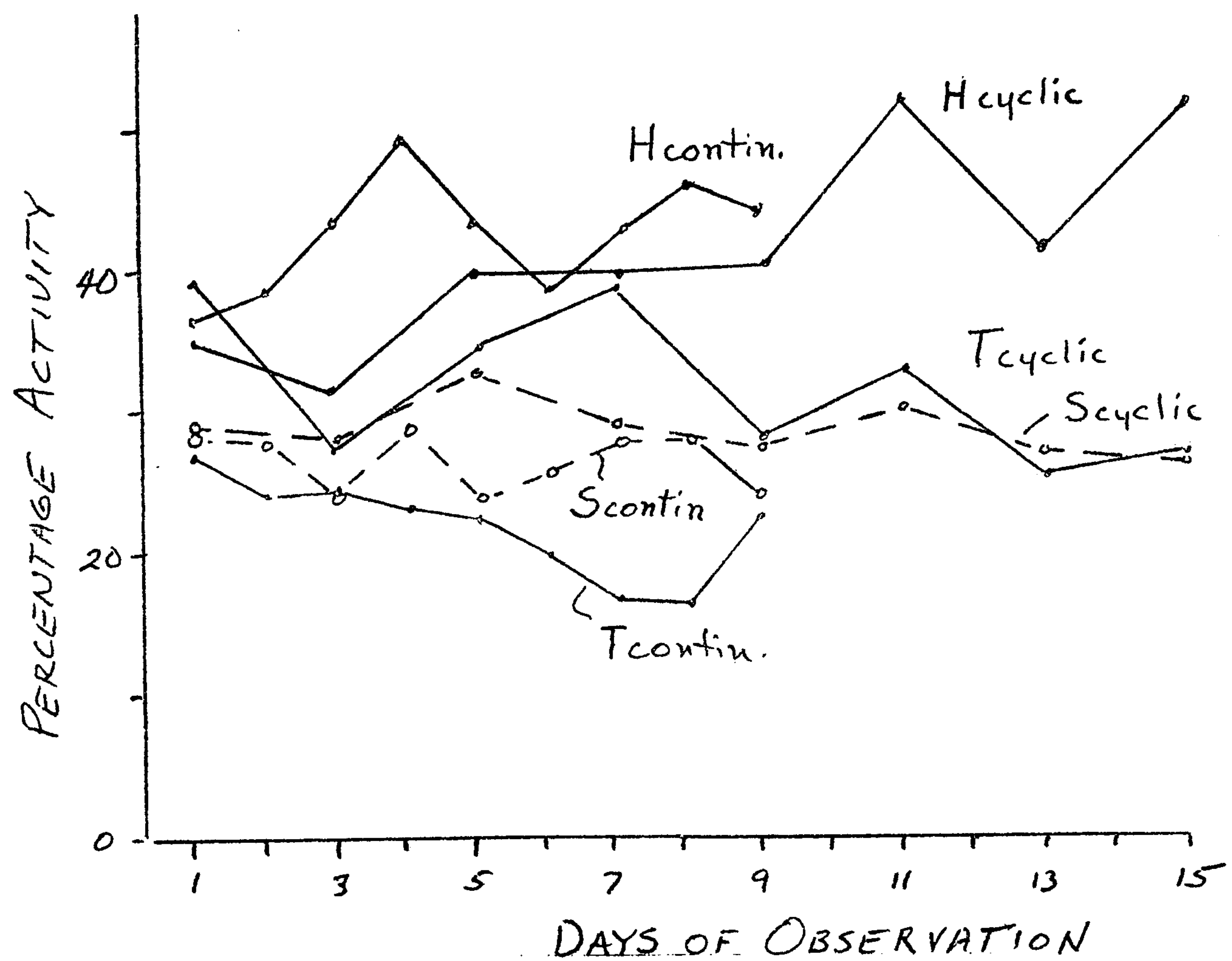

Fig. 1. Day by day trends in total activity of Hungry, Thirsty, and Satiated control $\underline{\underline{S}}s$ under either continuous deprivation or cyclic deprivation conditions.

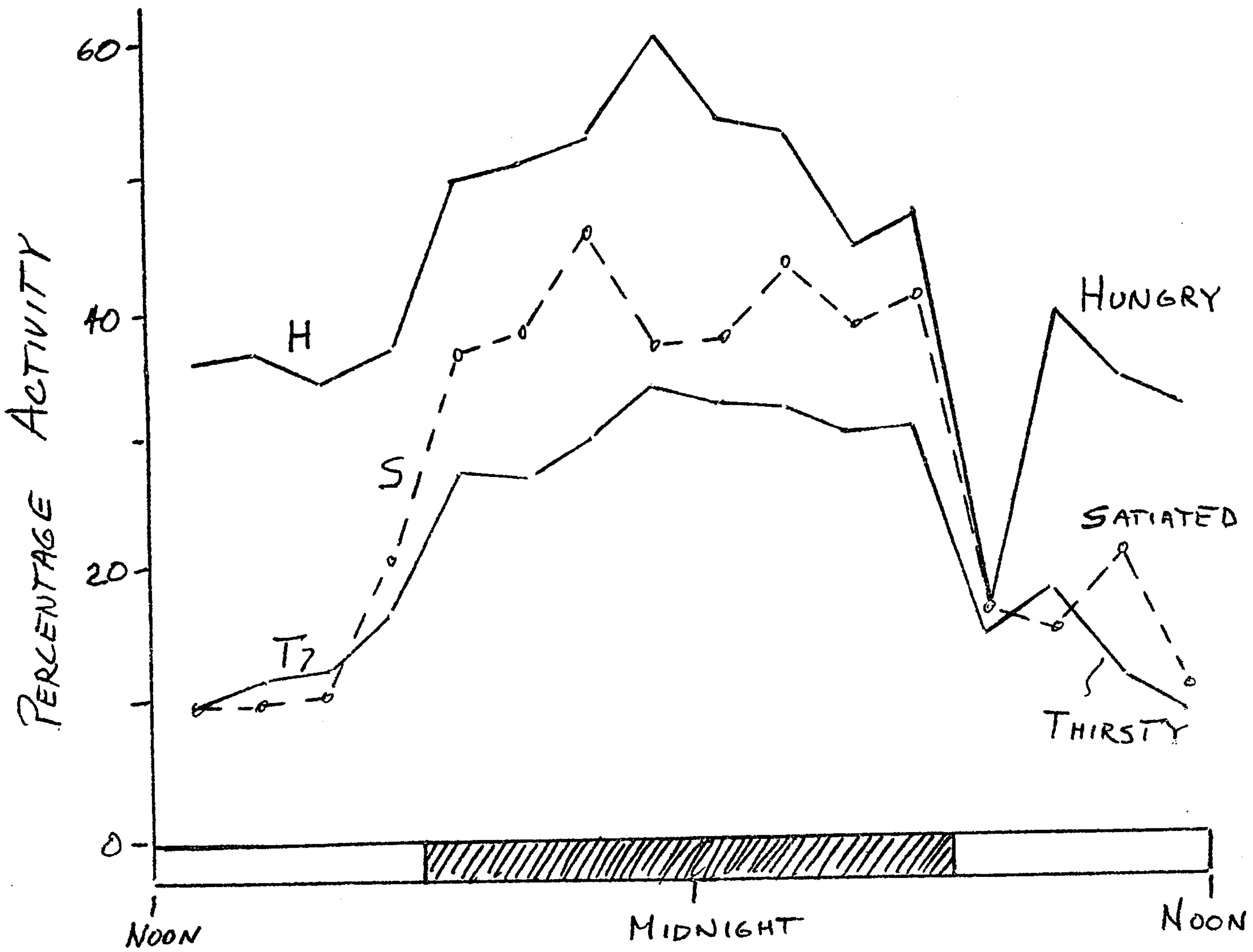

Fig. 2. Diurnal activity cycles of continuously deprived Hungry and Thirsty Ss and Satiated controls.

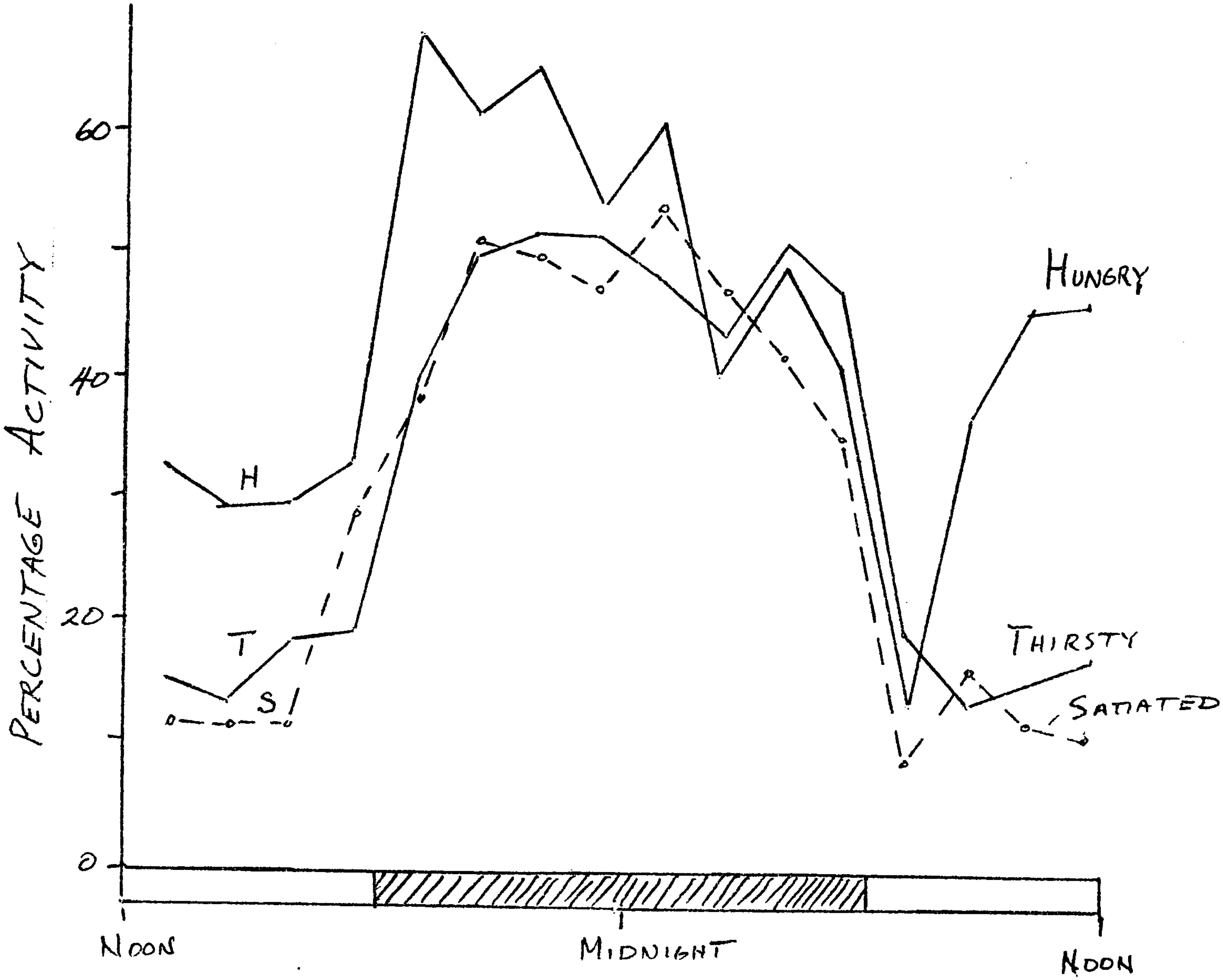

Fig. 3. Diurnal activity cycles of cyclically maintained Hungry and Thirsty $\underline{S}$s and Satiated controls.